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FOR THE WEST INDIES.

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GENERAL TREATMENT OF FUNGOID PESTS.

ISSUED BY THE COMMISSIONER.
1902.

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IMPERIAL
DEPARTMENT OF AGRICULTURE
FOR THE WEST INDIES.

THE GENERAL TREATMENT OF FUNGOID PESTS.

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PREFACE.

Amongst the enemies to be overcome by tropical planters the parasitic plants known as rots, moulds and mildews take a prominent place. It is impossible to ignore fungoid diseases as the aggregate loss caused by them to the sugar-cane, cacao and other industries amounts to several thousand pounds sterling annually.

The object of the present pamphlet is to afford a simple and clear account of the life-history of fungi so that the injury done by them may be readily recognized and suitable remedies applied before it is too late.

One of the most serviceable applications for fungoid diseases is what is known as 'Bordeaux Mixture.' Directions are given for the preparation of this (p. 37) as also for the use of knapsack and other spraying machines (pp. 38-39). Special attention is invited to

the directions given on pp. 41-43 for collecting and forwarding specimens for examination by this Department.

D. MORRIS,
Commissioner of Agriculture
for the West Indies.

September 10, 1902.

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THE GENERAL TREATMENT OF FUNGOID PESTS.

This pamphlet contains a brief account of the general measures to be adopted to check the diseases of plants in the West Indies which are caused by fungi. In order to render the subject clear and interesting, some preliminary experiments, which can be carried out with great ease, are described. By means of these it is possible to gain some insight into the nature of a fungus, the conditions which favour its development, the means by which it spreads, and consequently to appreciate the remedial measures discussed below.

A COMMON MOULD FUNGUS.

It is a matter of universal experience to find that during damp and wet weather,

articles such as boots and shoes become covered with 'mould', and that this mould disappears when the articles on which it grows are moved into a dry place. These moulds are examples of the class of plants known as fungi, and it will be convenient for our purpose to study one of these minute plants in some detail.

In order to do this we must take two glass tumblers, in the bottom of one of which is placed a pad of well-moistened rag or blotting-paper, and in the other a pad of dry rag or blotting-paper. The glass containing the wet rag or blotting-paper must be covered with a saucer and both of them should either be labelled or else stood on a piece of white paper on which pencil notes may be written. We can refer to the two glasses as the moist and the dry tumblers, respectively.

If we put a piece of bread and jam or, better, some slightly roasted ground-nuts or pea-nuts * in both of these glasses, taking care to cover the moist tumbler with the saucer,

* The seeds of *Arachis hypogaea* are known as earth, ground, or pea-nuts.

and put them in a shady place in the house, we shall notice in about forty-eight hours that the pea-nuts or the bread and jam in the moist tumbler become covered with a silky-white thread-like growth which develops with great rapidity. No such growth is to be noted in the dry tumbler.

The silky-white growth in the moist glass is a fungus* and one of the commonest moulds found all over the world. On looking at this growth carefully, when it first appears, it will be seen to be made up of minute branched threads or filaments.† These make up the growing part of the fungus and live at the expense of the materials in the pea-nuts or the bread and jam on which they appear.

If we carefully watch the silky growth in the moist tumbler, we shall notice on the third day, or perhaps late on the second day, that stouter threads grow up into the air from the web-like growth, and tiny greyish

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* A species of *Mucor*.

† These individual threads are known as *hyphae* (a Greek word meaning threads) and the whole matted growth of threads is known as a *mycelium* (from the Greek word meaning a fungus).

spherical swellings, about the size of a pin's head, appear at the free ends of these erect portions. These knobs soon change in colour and in a very few hours turn dark-brown and then nearly black. This stage is illustrated in Fig. 1, where one of these knobs is shown highly magnified. (A)

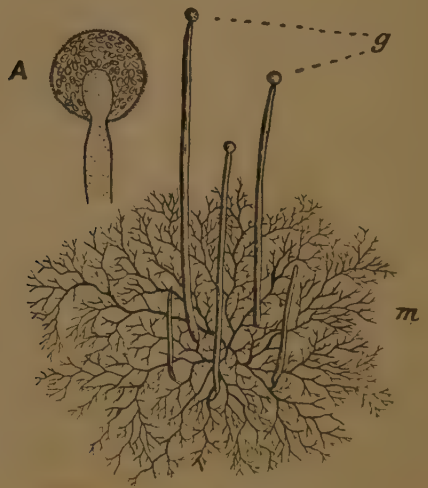

Fig. 1. A plant of a kind of *Mucor* showing the web like growth at *m* and the stout vertical threads bearing the spherical swellings at *g*. A, one of these swellings highly magnified showing the spores in its interior. (*After Brefeld.*)

If we touch several of these heads with a

piece of moist white paper, we shall see that it becomes blackened by a dusty looking material which comes from the dark-coloured heads. This black dust is made up of a large number of very minute round bodies known as *spores* * which are shown in Fig. 1. We can regard these spores for present purposes as the seeds of the fungus plant. Although, strictly speaking, spores and seeds are different from a scientific point of view, they serve a similar purpose, namely, that of giving rise to new plants. Just as new crops of corn (maize) are raised from seed, so new growths of fungi arise from spores.

The seeds (spores) of our mould fungus are formed, as we have seen, in great numbers, and it will be interesting to note the manner in which they spread. The outer skin of the black head becomes dry and brittle and finally bursts, scattering the seeds (spores) in all directions. They are so small that they can easily float in the air and be carried to a considerable distance by wind. If one of these spores falls on some moist surface, it germinates and, if a source of food is at hand,

* From a Greek word meaning a seed.

rapidly gives rise to a fungus growth identical with that which we have indicated above. On the other hand, the spores which fall on dry surfaces remain dormant, but often retain their power of germination for a long time.

Without going into further details about the fungus in question, it will be evident that two very important facts can be learnt about it. In the first place, *moisture is as necessary for the growth of a fungus as it is for any other plant.* This is proved by the fact that no silky growth appeared on the nuts or bread and jam in the dry tumbler. That the fungus seeds (spores) are really present in the dry tumbler can be proved by moistening the blotting-paper at the bottom and covering it with a saucer. In two days the fungus will appear and in three days it will have 'run to seed' as before. Just as in the case of other plants, moisture is necessary for the germination of the seed (spores) of a fungus and for its after development. In the absence of moisture the germination of fungus spores does not take place and therefore growth is impossible.

In the second place we see that *fungi grow from spores just as many other plants grow from seed.* Further these spores are so minute that they are easily distributed by wind. It is possible to show by suitable methods that a fungus spore gives rise to a fungus as clearly as it can be proved that an Indian corn seed develops into a corn plant.

These simple experiments enable us to understand why articles become 'mouldy' in damp weather or when stored in damp places, and also why the 'mould' disappears in dry weather. The spores of the common mould fungi are to be found almost everywhere and especially in dust. They germinate whenever there is sufficient moisture, and a new fungus growth or 'mould' results whenever there is a supply of food material at hand. If we move the mouldy articles into a dry place, the growth of the fungus stops for want of water or, in other words, it is killed by drought. These simple facts will be of great use when we come to consider how we can protect our cultivated plants from the fungi which attack them.

TWO GROUPS OF FUNGI—USEFUL AND HARMFUL.

The vast majority of the fungi, like the common mould we have dealt with above, are only capable of existence on the dead and rotting remains of plants and animals, or on the various materials derived from plants and animals such as bread, jam, leather, tobacco, etc. These fungi are known as *saprophytes* from two Greek words meaning plants which live on rotting remains. Such fungi never attack living plants and therefore do not give rise to plant diseases. Except when they live on and destroy articles which are of use to mankind, such as food-stuffs, timber, merchandise, articles of clothing, when we regard them as harmful, these saprophytes play a very useful part in the scheme of nature. They get rid of dead plant and animal remains by transforming them into simpler substances which are eventually made use of by a younger generation of plants. Unless the vast quantities of dead plant and animal remains were removed in this way, all life on this planet would soon become impossible. One group of these saprophytes, the yeasts, is of world-

wide importance in the manufacture of alcohol from sugars, and in bread making. We can regard such useful members of this group as fungi under domestication.

A few of the fungi attack living plants and animals and give rise to definite diseases. These are known as parasites, that is to say, plants which live at the expense of other organisms (plants or animals, as the case may be). It is with the means of limiting the ravages of fungi which cause diseases in useful plants that this pamphlet deals. Some of the fungi which attack animals are of use to the planter, notably those which destroy injurious insects and especially the group known as scale insects. It must be remembered however, that the fungoid diseases of insects are not of sufficient importance in keeping down these pests to obviate the necessity of adopting the direct measures suggested by entomologists. The success which has attended the artificial spread of the fungoid diseases of insects in a very few cases, such as the locusts of South Africa, has done harm to the question of the control of insect pests in general, as it has led to the idea that probably

every insect pest has some disease, which, if spread, will keep that pest sufficiently under control. Unfortunately this idea is not in accordance with the facts.

Further, in some cases parasitic fungi which attack plants are useful when the particular plant attacked happens to be itself a parasitic fungus. In the case of a yellow rust on the leaves of Cannas which is caused by a fungus, this parasite is in turn attacked by another fungus,* the fruits of which can be made out as black dots round the rusty spots. Just as some harmful insects have insect enemies, so some of the parasitic fungi are in turn attacked and are partly checked by other fungi.

It is proposed in the following pages to indicate, briefly, the more important fungoid diseases in the West Indies, and to lay stress on the remedies which are applicable, both on a large and a small scale, to check them. It will be convenient to deal with these diseases from the point of view of the part of

* The rust fungus is *Uredo Cannae*, while its natural enemy is a species of *Darluca*.

the plant attacked, and to consider them under the following heads :—

Root diseases.
Stem diseases.
Leaf diseases.
Fruit and seed diseases.

At the outset it must be remembered that when a plant is attacked by a fungus, the fungus is not the only active agent in the struggle. *Plants, when in health, possess a very considerable power of defence against all parasites, fungi included.* On the other hand, when, from various circumstances, plants become unhealthy, their power of resistance is much less and fungi often overcome them. To give a plant the best possible chance in the struggle therefore, it is imperative that the greatest care be taken to keep it in vigorous health. On this principle many of the remedies given below are based.

ROOT DISEASES.

Many of the useful plants of the West Indies are attacked by root diseases which are caused by fungi. Thus the sugar-cane, cacao, nutmeg, orange and other citrus plants,

mango, avocado pear, coffee, pine-apple, arrowroot, beans and peas, Central American rubber and others have definite root diseases, which in some cases cause much damage. The symptoms shown by plants attacked by these diseases are very similar and are, to some extent, characteristic.

The chief business of the roots of plants is to take up water and minerals (sometimes called 'plant food') from the soil for use in the leaves. While in a state of health, roots are generally able adequately to perform this duty, but when diseased they are never able to accomplish it. Consequently plants attacked by root diseases show all the symptoms associated with water and mineral starvation. Many of the leaves fall off, while those which remain show a lack of vigour and a certain amount of drying up at their tips and edges. In the case of trees there is a similar loss of leaves accompanied by dying back of the branches. Very similar results, however, are seen when plants are subjected to long continued drought or are placed in unsuitable soils and windy situations, so that these symptoms of drying up of leaves and dying back of branches do not necessarily point to

root diseases caused by fungi. Some further examination of the affected plants is necessary to be certain that root disease is the cause of the trouble. This can be made by examining the roots themselves. If attacked by fungi, they will be seen to be decayed or rotten or else covered with a whitish fungus growth generally more matted than that seen in the experiments described above. In the case of trees attacked by root diseases, a matted fungoid growth can sometimes be seen between the bark and the wood of the larger roots. Such a growth is very evident in the case of the root disease of the nutmeg and cacao in the West Indies.

Several of the fungi causing root diseases belong to the group which embraces mushrooms and toadstools, the highest group of the fungi. In the case of the common root disease of the sugar-cane, the fungus apparently concerned in the disease is a small toadstool which can be seen in large numbers at the base of the diseased shoots after rainy weather. A portion of the lower part of a sugar-cane shoot, attacked by root disease, on which these toadstools appear is shown in Fig. 2.

Fig. 2. A portion of the base of a shoot of a sugar-cane attacked by root disease bearing the toadstools of a fungus (a species of *Marasmius*) which apparently causes the disease. *(From Nature.)*

The fungi which cause root diseases can usually travel underground and thus spread the disease to other plants. Consequently in crops attacked by root disease, the diseased areas are more or less circular in shape.

The manner in which fungi interfere with the work of roots may be referred to. In plants like the sugar-cane, the roots are either attacked at the tip when young and thus prevented from developing, or else the fungus is

able to invade the central portions of the older roots and block up the minute tubes (vessels) through which the water and minerals, taken up from the soil, pass on their way up to the leaves. In the case of trees like the nutmeg, the fungus destroys the bark on the larger roots, thus preventing the food supplies sent down from the leaves from reaching the feeding roots, and also invades the wood, thus interfering with the upward passage of water and minerals to the leaf.

Remedies for Root Diseases.

(1) Drainage and Cultivation. Since roots are healthy only when the soil contains air and water in proper proportions, it will be evident that we cannot expect healthy root growth in an undrained and waterlogged soil containing little air. Air is especially necessary for the proper working of those parts of the roots which are sometimes referred to as feeding roots. *Drainage, by removing excess water and admitting air is therefore one of the first conditions to ensure healthy root development and freedom from root diseases.* Besides bringing about proper soil conditions for the crop, drainage, by removing excess

water prevents the luxurious development of fungi, since the crop can get on with less moisture than the fungi which attack its roots.

Of equal importance to drainage in this question is the physical condition of the soil. When this is unsuitable, there can be little doubt that this factor plays a great part in the development of the root system and the presence of disease. Both in permanent crops like cacao, and in temporary crops like the sugar-cane, the physical condition of a soil can be largely modified and improved by suitable cultivation. Drainage and cultivation are therefore the first remedies against root diseases. They at the same time assist healthy root development and also remove one of the conditions, namely, excessive moisture, which favours the growth of fungi.

(2) Starvation of the Fungus. A second general remedy is to starve out the particular fungus causing the disease in cases where root disease has already made its appearance. In temporary crops like the sugar-cane, this is done by removing and destroying the old stumps as far as possible, draining if neces-

sary, and thoroughly cultivating the soil and then growing a rotation crop before replanting in cane. In very bad cases more than one rotation crop is necessary before the fungus has been got rid of. In the case of trees like cacao and nutmeg, the diseased roots are dug up and destroyed, the ground forked and allowed to remain some time before replanting. In all cases where a fungus has to be starved out in this way, the application of lime materially assists in the process by hastening the decay of the plant remains in the soil on which the fungus in question could live.

(3) Isolation of Diseased Areas by a trench from the still healthy portion of the crop. A third general remedy is to isolate the affected areas by a trench so as to prevent the spread of the disease underground to the still healthy plants. In performing this isolation, care must be taken to dig the trench a suitable depth so as to pass below the surface roots. Nine inches to a foot would suffice in sugar-cane cultivation, while 18 to 24 inches would be required in the case of permanent tree crops like cacao

and nutmegs. In making this isolating trench the soil should be thrown on the diseased patch and not on the healthy area.

(4) Budding on Disease-resisting Stocks. In the case of the orange an almost universal disease known as 'foot-rot,' or 'mal-di-gomma' frequently destroys the bark at the surface and for some distance below the ground and causes much damage. Extensive outpourings of gum at the diseased regions accompany the disease. Several methods of treating the affected trees have been suggested with more or less success, but it has been found that the best results are obtained if the particular orange required is budded either on sour-orange or grape-fruit stocks, which are rarely attacked by this disease.

(5) Transplanting. This method has been found to give good results in the case of an obscure disease of pine-apples known sometimes as 'blight,' in which the roots often tangle round the stem in an extraordinary way. If the portion to which the tangle of roots is attached be cut off, the lower leaf bases removed, and the plant transplanted, good results often follow.

STEM DISEASES.

Perhaps the most important of the fungoid diseases of economic plants in the West Indies are included in the diseases of the stem. Both sugar-cane and cacao, the most important crops in the West Indies are attacked by several diseases of the stem. In addition the stems of some small seedlings are sometimes attacked by a fungus, which causes them to damp off, while there are several diseases of the underground stems of arrowroot and ginger.

The fungi which attack the stems of mature plants are generally of the class known as wound parasites, and gain entry to the stem at wounds made by boring insects, by high winds, by animals, by the fall of shade trees, and in careless wounding and pruning by workmen.

They cause damage by interfering with the processes going on in the stems of the plant attacked. They destroy the inner bark of trees like cacao and prevent the natural growth of the tree in thickness and also interfere with the supply of plant food sent down by the leaves to those portions of the

plant below the part attacked. Further, they attack and destroy the wood, interfering with the passage of water and minerals to the leaves and also diminishing the strength of the trunk. In plants like the sugar-cane, ginger and arrowroot, they not only interfere with the processes going on in the plant, but also attack and destroy the storehouse of reserve material in such stems.

Before discussing the remedies which are possible in the case of stem diseases, it will not be out of place to indicate the manner in which plants are naturally able to repair injuries to their stems and withstand the attack of parasites. Some of the remedies proposed have for their object the assisting of the plant in making the most of these natural protective powers.

How Injured Stems Protect Themselves.

The causes of injury to the stems of plants are numerous. Various boring and sucking insects such as the common borers and scale insects attack both aboveground and underground stems. High winds and the fall of shade and other trees often cause great

damage to cacao trees. Rolling stones on sloping hill-sides and small landslips also damage stems in some cases, while man himself, in careless pruning and fruit picking often causes injury.

It is well known that healthy and vigorous trees have the power of protecting themselves in several ways when their bark is wounded. Trees like the orange and cacao cover their wounds with gum and then proceed to grow fresh bark over the wound by which it is rapidly covered. Although this natural protection is sometimes sufficient against wound parasites, it is evident that this repair takes place at the expense of the tree, and therefore on this account alone, wounds should be avoided.

When however trees are not in a vigorous condition, nor are at a time of vigorous growth, as in the dry season or when large branches have been removed in pruning, they are less able to protect themselves against parasites and unless they are assisted to ward off attack, disease frequently results This may either destroy the tree altogether or else greatly interfere with its bearing powers.

The need of assisting trees to withstand disease is therefore evident.

The production of new wound-bark—often called a *callus*—is of interest. We know that the bark of such a tree as the lime can be easily peeled off, leaving the moist wood underneath. The growing part of stems and branches of trees—this tissue is known as the *cambium*,—is situated between the bark and the wood, and is so tender that it is destroyed when the bark is removed. Now when the bark is wounded, this growing part of the stem, or as it is called, the cambium, proceeds to form new bark at the edges of the wound, which gradually grows inwards and covers up the wounded surface. When a lateral branch is removed, new bark is also formed which gradually grows over the cut surface. The gradual covering of such a wound is shown in Fig. 3.

Fig. 3. A wound, produced by the removal of a branch, which is partly covered by the growth of wound-bark (*b*) from the edges. (*After Hartig.*)

After a wound is covered in this way all danger of the entry of parasites is at an end. It is only however, when the greatest care is taken in pruning that the tree is able to cover its wounds at all. In addition the cut surface requires to be protected to keep out parasites during the healing process.

Principles of Pruning. The main principles involved in the operation of pruning may be referred to. Side branches should always be removed as near as possible to the parent stem (as in Fig. 3) and the final cut surface should slope in such a way as to allow rain-water to flow off easily. On no account should the branch be allowed to fall by its own weight, else the strain will destroy the delicate cambium at the region where fracture takes place and thus delay the healing process. The branch should be supported and a suitable uppercut should be made to prevent splitting. If a saw is used the sides of the cut must be trimmed with a sharp knife or cutlass so as to remove the cambium killed by the vibrating action of the saw. The cut surface should be coated with tar so as to prevent the entry

of rain-water and the consequent danger of the germination of fungus spores on the surface of the wound. Heavy pruning should be done, if done at all, in the dry season, as at this period the wood absorbs tar best, the danger of the entry of parasites on account of the absence of moisture is least, and the tree is best able to bear the interference in growth caused by the removal of a portion of its branches.

The results of careless pruning are very marked. Even if the side branches are removed as near to the tree as possible, but the cambium is destroyed round the wound, the healing process is greatly retarded and decay is almost bound to take place. If the side branch is cut off a foot or so away from the main stem, and especially if the cut surface is jagged and uneven, the stump dies, and parasites entering at the cut surface set up decay which quickly spreads to the trunk itself. In such cases the wound hardly ever heals. In Fig. 4 one of these dead stumps or snags is shown to which is attached the fruits *(f)* of a wound parasitic fungus, a species of *Polyporus*, which had invaded and greatly

damaged the tree. In many such cases decay is assisted by various boring beetles and ants.

Fig. 4. A stump of a dead side branch of the lime bearing the fruits (*f*) of a wound parasitic fungus. (*From Nature.*)

Indeed, it is not too much to say that the evils which result from bad pruning are far greater than the good derived from effective pruning, so that it would appear better not to prune at all rather than to carry out the operation in a careless manner. Left alone in this respect trees prune themselves to a great extent in the struggle for existence which goes on between the branches themselves.

Remedies for Stem Diseases.

The general remedies applicable to the diseases of the stem are as follows :—

(1) Removal of the Sources of Infection. The first general remedy is obviously to destroy, as far as possible, the portions of the plant on which the fungi causing disease occur. Nearly all wound parasites are capable of living on the dead remains of the plants they attack and of spreading therefrom to the healthy ones. Hence if we destroy as far as possible this dead material, the chances of the spread of the disease are greatly diminished. Further, in those cases where tropical fungi (as in the case of one of the cacao pod parasites), form resting spores to tide over unfavourable periods, such resting spores occur in these dead remains and are therefore destroyed when this material is burnt. In tree cultivations like cacao, all dead branches and trees should be periodically removed from the plantation and burnt, and care should be taken to cut down all dead trees level with the ground, otherwise harmful fungi are likely to live on the old stumps which thus become a source of danger to

surrounding trees. In cane cultivation, the rotten canes which are frequently covered with the spores of the 'rind fungus' should be stacked in heaps and, after treatment with kerosene oil, set on fire. When this is impracticable they should be crushed in the mill and the megass burnt. The destruction of dead remains applies both to aboveground and to underground stems such as arrowroot and ginger which are attacked by fungoid diseases. Not only should diseased plant remains be destroyed but also all other dead matter should either be buried or else burnt. This recommendation applies especially to small plots and gardens.

(2) The Control of Boring Insects. Indirectly the attacks of borers, by producing wounds, favour the spread and the extent of damage done by wound parasitic fungi. Sugar-cane, cacao, limes and other crops are attacked by various boring insects which produce wounds at which the spores of wound parasites can readily germinate and set up disease. The methods applicable to the control of boring insects are given in Pamphlet No. 5 of this series entitled *General Treatment of Insect Pests.*

(3) Protection of Wounds by Tar. To assist trees like the cacao and orange to withstand the attacks of parasites, the wounds made by pruning, by heavy winds and the fall of shade trees should be tarred. In this way rain-water is kept out of the wound and the danger of the germination of fungus spores greatly diminished.

(4) Protection of Cuttings. In sugar-cane cultivation, the cuttings used in planting are very apt to be destroyed in the ground by fungi which enter principally at the cut ends. It has been found that if the cuttings are dipped in Bordeaux mixture * and the cut ends coated with tar, they are protected from fungoid and insect attack.

(5) Removal of Diseased Tissue. When cacao trees are attacked by the canker fungus it is practicable to cut out the diseased claret-coloured bark, tar the wound and save the tree. Cankered spots are easily noted by the fact that the stem 'bleeds' at the diseased places and that the affected

* Directions as to the preparation of Bordeaux mixture are given on page 37 of this pamphlet.

bark is deep-red in colour. The pieces of diseased bark cut out in this way should be carefully burnt and the cutlasses and knives used in the process should be cleaned before being used for other purposes such as pruning.

(6) Protection of Seedlings. When seedlings are planted too thickly and when the amount of watering is excessive, they frequently 'damp off' or decay with great rapidity. This is due to a fungus which luxuriates under these moist conditions and rapidly destroys the delicate stems of the seedlings causing them to become top-heavy and to fall over. The disease can be checked by removing and destroying the affected plants, by thinning out the remaining seedlings, and by avoiding too frequent waterings. In this way light and air are admitted, the seedlings become more robust and the diminution of moisture, while not interfering with the growth of the seedlings, is sufficient to check the fungus. In order to kill the resting spores of this 'damping off' fungus and prevent a return of the disease, the soil in the seed beds or boxes should be baked by

burning rubbish on the surface, the great heat serving to destroy these spores.

LEAF DISEASES.

The leaf diseases of economic plants in the West Indies, although numerous, are not so destructive as those which attack the root and stem. The leaf-sheaths and leaves of the sugar-cane are attacked by several different fungi, while the leaves of many fruit and ornamental trees are covered with black blight, a fungus which lives on the excretion of scale insects. Although not so destructive as the scale insects which give rise indirectly to its presence, black blight does a certain amount of damage by cutting off light from the leaves and blocking up their pores. Canna leaves are generally attacked by a rust fungus which produces yellow spots on the leaves, while yams are frequently damaged by a fungus which attacks the vines and leaves, producing black spots. The leaves of roses and grape vines are also sometimes attacked by white 'mildews' which cause the leaves to shrivel up.

Remedies for Leaf Diseases.

(1) Removal of Black Blight. This is best removed by spraying the tree with a suitable wash to destroy the scale insects to which the fungus owes its presence. Information as to the selection, preparation and application of washes for this purpose is given in Pamphlet No. 7 of this series entitled *Scale insects of the Lesser Antilles.* Part I.

(2) Preventive Spraying with Bordeaux mixture and ammoniacal solution of copper carbonate. This might be tried in the case of yams when attacked by the leaf and vine disease referred to above. The plants should be sprayed with Bordeaux mixture (for preparation and application see p. 37) on the first indication of the disease, and the spraying repeated after eight or ten days. The mixture must be applied with a knapsack sprayer, fitted with the Bordeaux nozzle, and should reach both sides of the leaves in the form of a fine, mist-like spray. In order to determine the value of this treatment, the yield of yams per acre on sprayed and unsprayed areas should be compared, and also the value of the increased yield obtained by the treat-

ment, compared with the cost thereof. Bordeaux mixture, on account of the whitewashed appearance of the treated plants, cannot be used in the case of ornamental and greenhouse plants. In its place an ammoniacal solution of copper carbonate (for preparation see p. 38) which is a clear blue liquid, may be employed in such cases.

(3) Application of Flowers of Sulphur. In cases of mildew, such as that seen on the leaves of roses and grape vines, the application of flowers of sulphur gives good results. It should be applied, when the leaves are wet, by means of a tin canister perforated by small holes, by placing it in a sack and beating it, or by means of a special machine for the purpose known as the 'Little Giant Powder Gun' which may be obtained from Messrs. Peter Henderson & Co., 35, Cortlandt Street, New York, price $5. The price of sulphur in New York is generally 3 cents a pound wholesale, and 6 to 10 cents retail. The mildews on roses and grape vines can also be controlled by spraying with the ammoniacal solution of copper carbonate mentioned above.

(4) Destruction of Diseased Material. Just as in the case of stem and root diseases, all diseased leaves should be collected and burnt so as to remove the source of infection. This is best performed by burning and burying them.

FRUIT AND SEED DISEASES.

Besides the diseases of growing fruits such as those of cacao pods, the sooty mould or black blight of the orange and the rot of tomatos, many seeds and fruits are very liable to destruction by fungi after collection, and especially during transport. The germinating power of many seeds is often destroyed from this cause. The question of the preservation of tropical fruits like bananas, pine-apples and oranges during transport is largely a question of the prevention of fungoid diseases. Conditions have to be found such that decay due to these causes is prevented until the fruit is placed on the market.

Remedies for Fruit and Seed Diseases.

Diseases of Cacao Pods. Diseased cacao pods are recognized by the black or brown

colour of the affected pods and the mouldy character of the beans therein. These diseases may be kept in check by burying all the old husks or pods under the trees, and by burning all the diseased pods found on the trees. It is necessary to bury all the old husks since the fungi which cause cacao pod diseases are apt to live on these old husks and spread therefrom to the healthy pods. If in damp situations where the conditions are very favourable to the spread of these diseases the above measures are insufficient, the healthy pods should be sprayed with Bordeaux mixture and the number of shade trees, if possible, diminished.

(2) Sooty Mould or Black Blight of the Orange. This is due to the black blight fungus which follows certain scale insects, and, by disfiguring the fruit, greatly depreciates its value. It can be prevented by the use of a suitable spray like rosin-wash, which quickly kills the scale insects to which it is indirectly due.

(3) Rot of Tomatos. A disease of tomatos, probably caused by bacteria, occurs in the West Indies. The fruits begin to decay

at the point where the remains of the dead flower occur, and the rot gradually spreads. Some varieties appear to resist the disease while others are badly attacked. The best remedies appear to be to burn the affected fruits and plants and to cultivate those varieties which resist the disease.

(4) Preservation of Seeds and Cuttings. Seeds for planting are often destroyed by fungi during transport and their germinating power destroyed. The inroads of fungi may be prevented to some extent by packing the seeds in dry cocoa-nut refuse or in weathered charcoal. In any case no time should be lost in transit and before planting, as the germinating power of tropical seeds, even when kept under the best conditions, seems to fall off very rapidly. Sugar-cane cuttings are also liable to rapid destruction by fungi during transit. This may be prevented by treating the cuttings, as soon as they are prepared, with Bordeaux mixture, then coating the cut ends with tar and shipping them in well-ventilated barrels.

(5) Preservation of Fruits during Transport. Several conditions are necessary

for the successful transport of tropical fruits. In the first place, fruit must be picked before it is ripe and kept a few days before packing so as to dry sufficiently to prevent the development of fungi on the voyage. Secondly, each fruit or bunch of fruits must be separated from the rest by paper or some other suitable packing material so as to absorb moisture and to prevent the spread of the fungi causing decay, in case a few of the fruits are attacked. Thirdly, the fruit must be transported in a cool, well-ventilated chamber so as to delay the ripening process and also to remove the conditions, namely, excessive moisture and a high temperature, which favour the development of the fungi of decay. In addition care must be taken not to damage the fruit before shipping, to collect it in dry weather, and to pack it in such a manner as to prevent crushing. Unless these precautions are taken, the natural powers of resistance of sound fruit are practically destroyed, since any chance spores find abundant moisture and food on the crushed and bruised surfaces, and decay rapidly results.

PREPARATION, APPLICATION AND COST OF FUNGICIDES.

The fungicides mentioned above are extremely easy to prepare and need cause no trouble whatever.

Bordeaux mixture is best prepared by the following formula:—

Copper Sulphate (blue stone) ...	6 lb.
Unslacked lime	4 lb.
Water	50 gallons.

The 6 lb. of copper sulphate (blue stone) are dissolved in 25 gallons of water in a *wooden* tub or barrel. It is best to tie the crystals of blue stone in a piece of sacking and suspend it in the water from a stick laid across the top of the barrel. At the same time 4 lb. *of freshly-burnt* unslacked lime are slowly slacked and the resulting paste made up to 25 gallons with water and well stirred. Next the lime wash and solution of blue stone are slowly poured together into a third tub or barrel holding from 50 to 60 gallons. When the mixing is complete, the blue liquid is stirred for a minute and tested by placing therein a clean bright knife-blade for one minute. If the knife-blade remains bright,

the Bordeaux mixture is safe, but if it becomes covered with a deposit of copper more lime milk must be added until this deposit ceases to form. Prepared in this way the blue substance in the mixture does not settle readily and the mixture does not require much stirring before use.

An ammoniacal solution of copper carbonate is prepared from—

Water	45 gallons.
Strong water of ammonia	3 pints
Copper carbonate	5 ounces.

The copper carbonate is made into a thin paste by adding a pint and a half of water. The ammonia water is then slowly added and a deep blue solution is obtained which is made up with water to 45 gallons.

When plants have to be treated, these preparations are best applied by a spraying machine. When only a few plants are sprayed a good syringe may be employed. The object in view is to wet uniformly the plant with the liquid, and this can only be done by the fine mist-like spray produced by a good spraying machine. One of these

machines consists of a reservoir for the fungicide, a pump and a hose terminating with a suitable nozzle for producing the spray. A suitable form is the 'Success' knapsack sprayer fitted with the Bordeaux nozzle which can be strapped on the shoulders. (Fig. 5). The machine can be carried, the pump worked and the spray directed by one man. The Success knapsack sprayer can be obtained from Messrs. Peter Henderson and Company, 35, Cortlandt Street, New York, for $11.

Fig. 5. 'The Success' Knapsack Sprayer.

It is important to wash out the working parts of the spraying machine after use with clean water so as to prevent corrosion.

Cost of Materials. The retail prices in London and New York of the constituents used in these fungicides are given below.

The local prices would probably be nearly double these amounts.

Copper sulphate ...	...	5 to 6 cents per lb.
" carbonate...	...	48 " "
Flowers of sulphur	...	6 " "
Strong water of ammonia		12 cents per pint.

In Barbados unslacked lime is sold at 15 cents per 40 lb. The wholesale price of blue stone in England and America is 25*s.* per cwt. and that of flowers of sulphur 14*s.* per cwt. Where unslacked lime cannot be obtained, the temper lime used in sugar manufacture may be employed. The cost of this is about one cent per pound. At local (Barbados) prices, the cost of 50 gallons of Bordeaux mixture works out at 72 cents.

INTRODUCTION OF NEW PESTS.

There are several well-known and destructive fungoid diseases which are known to attack some of the useful plants which grow in the British West Indies but which so far do not seem to have made their appearance in these Colonies. The witch broom disease of cacao in Surinam, the coffee-leaf

disease of Ceylon, the onion mildew of Bermuda and elsewhere, the potato leaf-disease, the disease of vanilla in the Seychelles may be mentioned as examples of destructive diseases which so far do not seem to have appeared in the British West Indies. The best means of preventing their introduction would be to limit the importation of the useful plants concerned from places where these diseases occur, to the authorities of the various Botanic Gardens. Under these circumstances such imported plants would be planted separately, and kept under observation so that if disease occurred, it could be promptly dealt with. In this way the chances of introducing new diseases are much less than if no check whatever is placed on plant introduction.

COLLECTING AND FORWARDING SPECIMENS.

Specimens of plants attacked by fungoid diseases may be forwarded for examination through the Curator of the Botanic Station or any officer of the Department of Agriculture. In order that the specimens may reach Barbados in the best possible condition, some

care is necessary in their collection and packing. Unless this is taken, much time and labour are often wasted in the examination of unsuitable material.

When specimens of moist vegetable matter are packed in boxes or sent in envelopes they speedily become covered with saprophytic growths which frequently obscure all traces of the original cause of disease and render the specimens worthless. This is especially the case when the material has been collected some days before the closing of the mails for Barbados.

Fresh specimens of diseased plants should either be suitably dried and sent in a well-ventilated package or, preferably, placed in methylated spirits, high wines or rum immediately after collection and forwarded in a bottle or corked tube. When leaves, buds or twigs are attacked, the specimens should show as many stages of the disease as possible. When fruits, stems or roots are attacked, diseased pieces showing all stages should be cut out and placed in spirit as before.

Specimens of bark, wood and large fungus fructifications which are dry should be

wrapped in soft paper and sent in a well-ventilated package. If they are not dry they should be placed in the sun and sent as above. When it is considered desirable to send very large specimens such as portions of branches, stems, roots of trees or whole cacao pods, these should be collected as late as possible before the mail steamer leaves, and sent in a well-ventilated case.

Full notes should be sent giving details of the time of appearance of the disease, the locality, the damage done, the part attacked and also the date when the specimens were collected.

All specimens and correspondence intended for the Head Office should be addressed :—

THE COMMISSIONER,
Imperial Department of Agriculture
for the West Indies,
Barbados.